[001] # MULTI-STEP TRANSMISSION

[002]

[003]

[004] The present invention relates to a multi-step transmission in planetary construction, especially an automatic transmission for a motor vehicle according to the preamble of patent claim 1.

[005]

[006] Automatic transmissions, especially for motor vehicles, include planetary gear sets according to the state of the art, which are shifted using friction or shifting elements such as couplings and brakes; are usually connected with a starting element subject to a slip effect and are optionally provided with a bypass clutch, such as a hydrodynamic torque converter or a hydraulic coupling.

[007] A transmission of this type is revealed in EP 0 434 525 A1. It basically includes an input shaft and an output shaft, which are arranged parallel to each other, double planetary gear sets arranged concentrically in relation to the output shaft and five shifting elements in the form of three clutches and two brakes, whose selective locking respectively determines in pairs the different gear reductions between the input shaft and the output shaft. Hereby, the transmission has a front-mounted gear set and two power paths so that six forward gears can be attained through the selective engagement in pairs of the five shifting elements.

[008] Two clutches are needed, in connection with the first power path to transmit the torque from the front-mounted gear set to two elements of the double planetary gear set. These are basically arranged behind the front-mounted gear set in the direction of the double planetary gear set in the direction of the power flow. A further clutch is provided, in connection with the second power path, which detachably connects this with a further element of the double planetary gear set. The clutches are arranged in such a way that the internal disk support forms the output.

[009] Furthermore, a compact multi-step transmission in planetary construction, especially for a motor vehicle, is known from the publication US 6,139,463, which

has two planetary gear sets and one front-mounted gear set, as well as three clutches and two brakes. Two clutches C-1 and C-3 are provided with this known multi-step transmission in connection with a first power path for transmitting the torque from the front-mounted gear set to the two planetary gear sets. The external disk support or the cylinder or the piston or the pressure compensation side of clutch C-3, is connected with a first brake B-1. Moreover, the internal disk support of the third clutch C-3 is connected with the cylinder, or piston or pressure compensation side of the first clutch C-1, whereby the internal disk support of the first clutch C-1 is arranged on the output side, and is connected with a sun wheel of the third planetary gear set.

[010] Additionally, a multi-step transmission is known from DE 199 49 507 A1 of the Applicant, in which two non-shiftable, front-mounted gear sets are provided on the input shaft, which generate two speeds on the output side that can, in addition to the speed of the input shaft, be shifted selectively to shiftable double planetary gear sets acting on the output shaft through the selective closing of the shifting elements in such a way, that in each case only one shifting element of the two shifting elements just activated must be engaged or disengaged for shifting from one gear into the respectively next following higher or lower gear.

[011] Furthermore, an automatically shiftable, motor vehicle transmission with three spider supported planetary gear sets, as well as three brakes and two clutches for shifting six forward gears and one reverse gear, and with an input shaft, as well as an output shaft, is known from DE 199 12 480 A1. The automatically shiftable motor vehicle transmission is constructed in such a way that the input shaft is directly connected with the sun wheel of the second planetary gear set, and that the input shaft can be connected with the sun wheel of the first planetary gears through the first clutch, and/or through the second clutch with the planet carrier of the first planetary gear set. In addition or as an alternative, the sun wheel of the first planetary gear set can be connected through the first brake with the housing of the transmission and/or the planet carrier of the first planetary gear set through the second brake with the housing and/or the sun wheel of the third planetary gear set through the third brake with the housing.

[012] The present invention is based upon the objective of proposing a multi-step transmission of the type stated above, in which the construction effort is optimized and, moreover, the degree of efficiency in the main driving gears is improved with respect to drag and gearing losses. Additionally, low torques are supposed to act on the shifting elements and planetary gear sets in the multi-step transmission of the invention, and the speeds of the shafts, shifting elements, and planetary gear sets are supposed to be kept as low as possible. Furthermore, the number of gears, as well as the transmission ratio spread should are supposed to be increased.

[013] This objective is accomplished in accordance with the invention through the features of patent claim 1. Further advantages and beneficial embodiments will emerge from the dependent claims.

[014]

[015] A multi-step transmission in planetary construction is proposed, according to the invention, which has an input shaft and an output shaft that are arranged in a housing. Furthermore, at least three spider supported planetary gear sets, at least seven rotational shafts and at least six shifting elements, including brakes and clutches, are provided, whose selective engagement effects various reductions between the input shaft and the output shaft so that preferably seven forward gears and one reverse gear can be realized.

[016] In accordance with the present invention, in connection with the multi-step transmission, it is provided that the drive takes place through a shaft, which is continuously connected with an element of the first planetary gear set, whereby a further element of the first planetary gear set is continuously connected with the housing; that the output is effected through a shaft, which is connected with the planet carrier of the second planetary gear set and the ring gear of the third planetary gear set. Furthermore, with the multi-step transmission of the invention, it is provided that a further shaft is continuously connected with the planet carrier of the third planetary gear set; that a further shaft is continuously connected with the ring gear of the second planetary gear set, and a further shaft is continuously

connected with the ring gear of the first planetary gear set; that a further shaft is continuously connected with the sun wheel of the second planetary gear set, and that a further shaft is continuously connected with the sun wheel of the third planetary gear set, whereby the planetary gear sets are coupled with shafts and shifting elements. Hereby, the input shaft of the invention can either be connected with the planet carrier or with the sun wheel of the first planetary gear set, whereby the fixed connection of the first planetary gear set to the housing is achieved via the sun wheel or the planet carrier of the first planetary gear set.

[017] According to the invention, the second planetary gear set and the third planetary gear set are realized as minus planetary gears; the first planetary gear set is a plus planetary gear set.

[018] Suitable reductions, as well as a considerable increase of the overall ratio spread of the multi-step transmission, are the result of the configuration of the multi-step transmission in accordance with the invention, owing to which an improvement in driving comfort and a significant reduction in fuel consumption are brought about.

[019] The multi-step transmission of the invention is suitable for any motor vehicle, especially for passenger cars and for commercial motor vehicles, such as trucks, buses, construction vehicles, rail vehicles, caterpillar vehicles and the like.

[020] In addition, the construction expenditure is considerably reduced with the multi-step transmission of the invention through a low number of shifting elements, preferably four clutches and two brakes. With the multi-step transmission of the invention, it is advantageously possible to conduct a starting operation with a hydrodynamic converter, an external starting clutch or also with other suitable external starting elements. It is also conceivable to enable a starting procedure with a starting element incorporated into the transmission. Preferably a shifting element, which is activated in first gear and in the reverse gears, is suitable.

[021] In addition, a good degree of efficiency in the main driving gears is achieved with the multi-step transmission of the invention with respect to drag and gearing losses.

[022] Moreover, low torque is present in the shifting elements and the planetary gear sets of the multi-step transmission, due to the wear and tear on the multi-step transmission, is advantageously reduced. Furthermore, correspondingly small dimensions are made possible due to the low torque, due to the required space and the corresponding costs can be reduced. In addition, low speeds are also present on the shafts, shifting elements and planetary gear sets.

[023] Therefore, the transmission of the invention is designed in such a way that adaptability to different power train configurations in the direction of the power flow, as well as with respect to space, is made possible.

[024]

[025] The invention will be explained in greater detail below by way of example on the basis of the drawings, wherein:

[026] Fig. 1 represents a schematic view of a preferred embodiment of a multi-step transmission of the invention;

[027] Fig. 2 represents a schematic view of an additional preferred embodiment of a multi-step transmission of the invention;

[028] Fig. 3 represents a shifting diagram for the multi-step transmission of the invention in accordance with Fig. 1 and Fig. 2;

[029] Fig. 4 represents a schematic view of a further preferred embodiment of a multi-step transmission of the invention; and

[030] Fig. 5 represents a schematic view of a further preferred embodiment of a multi-step transmission of the invention.

[031]

[032] Figs. 1 and 2 show a multi-step transmission of the invention with an input shaft 1 (An) and an output shaft 2 (Ab), which are arranged in a housing G. Three spider supported planetary gear sets P1, P2, P3 are provided. The second planetary gear set P2 and the third planetary gear set P3 are constructed as minus planetary gear sets. The first planetary gear set P1 is constructed as a plus planetary gear set in accordance with the invention.

[033] As apparent from Fig. 1 and 2, only six shifting elements, namely a brake 03, and five clutches 13, 36, 45, 47 and 67 are provided.

[034] Selective shifting of seven forward gears and a reverse gear can be realized with the shifting elements. The multi-step transmission of the invention has a total of seven rotational shafts in accordance with Fig. 1, namely shafts 1, 2, 3, 4, 5, 6, and 7.

[035] In accordance with the invention, it is provided with the multi-step transmission, according to Fig. 1, that the drive takes place through shaft 1, which is continuously connected with the sun wheel of the first planetary gear set P1, whereby the planet carrier of the first planetary gear set P1 is continuously connected with the housing G. The output takes place through shaft 2, which is connected with the planet carrier of the second planetary gear set P2, and the ring gear of the third planetary gear set P3. Furthermore, shaft 3 is continuously connected with the planet carrier of the third planetary gear set, and shaft 4 is continuously connected with the ring gear of the second planetary gear set P2. In addition, shaft 5 is continuously connected with the ring gear of the first planetary gear set P1. According to the invention, the additional rotational shaft 6 is continuously connected with the sun wheel of the second planetary gear set P2, whereby shaft 7 is continuously connected with the sun wheel of the third planetary gear set P3.

[036] With the multi-step transmission of the invention, shaft 3 can be coupled onto the housing G through the brake 03. The clutch 13 connects shaft 1 and shaft 3 detachably with one another. Shaft 3 and shaft 6 are detachably connected with each other through clutch 36. Furthermore, clutch 45 detachably connects shafts 4 and 5; clutch 47 detachably connects shafts 4 and 7 with each other, whereby a further clutch 67 is provided, which detachably connects shaft 6 and shaft 7.

[037] A further embodiment of the multi-step transmission of the invention is shown in Fig. 2. The only difference, as compared to the embodiment according to Fig. 1, consists in that shaft 1 is connected with the planet carrier of the first

planetary gear set P1, and that the sun wheel of the first planetary gear set P1 is continuously connected with the housing G.

[038] A shifting diagram of the multi-step transmission of the invention, in accordance with Figs. 1 and 2, is represented in Fig. 3. A respective reduction i of the individual gear stages and the stage progressions φ to be determined on their basis can be inferred by way of example. Furthermore, it can be inferred from the shifting diagram that double shifts can be avoided with sequential modes of shifting, since two adjacent gear steps respectively use two shifting elements in common.

[039] The brake 03 and the clutches 45 and 67 are activated for the first gear. The second gear results from brake 03 and the clutches 36 and 45, and the third gear from clutches 36, 45, and 47. In the fourth gear, clutches 13, 36, and 45 are activated. According to the Fig. 3, the fifth gear results from the closing of the clutches 13, 45, and 67; the sixth gear requires the combination of the clutches 13, 47, and 67. For the seventh gear, clutches 13, 45, and 47 are required, whereas the reverse gear results from the closing of the brake 03 and clutches 45, and 47.

[040] According to Figs. 1 and 2, the fixed connection of the ring gear of the first planetary gear set P1 to the housing G can be replaced by a detachable connection, preferably by means of a brake. This is shown in Figs. 4 and 5, by way of example, which correspond to the embodiments according to Fig. 1 and/or Fig. 2, with the difference that the connection of the planet carrier of the first planetary gear set P1 with the housing G is detachably realized by means of a brake 00.

[041] Hereby, an electric machine or an additional suited, drive source may be arranged on the shaft 0, which was detached by means of the brake 00.

[042] It is possible, in accordance with the invention, to provide additional free wheels at each suitable position of the multi-step transmission, for example, to be connected between a shaft and the housing or about two shafts, if need be.

[043] It is possible through the mode of construction of the invention to arrange the input and output on the same side of the transmission or the housing

preferably for transverse, front wheel, longitudinal, rear longitudinal or all-wheel drive arrangements. Moreover, an axle differential and/or an inter-axle differential can be arranged on the input side or on the output side.

[044] The input shaft 1 can be separated by a clutch element from a drive motor as needed within the framework of an advantageous further development, whereby a hydrodynamic converter, a hydraulic clutch, a dry starting clutch, a wet starting clutch, a magnetic powder clutch or a centrifugal clutch can be used as clutch element. It is also possible to arrange a starting element of this type behind the transmission in the direction of power flow, whereby, in this case the input shaft 1 is continuously connected with the crankshaft of the motor. According to the invention, the starting procedure can take place using a shifting element of the transmission. Preferably the brake 04, which is activated in the first forward gear, as well as in the first reverse gear, can be used.

[045] The multi-step transmission of the invention moreover allows for the arrangement of a torsion vibration damper between the motor and transmission.

[046] A wear-free brake, such as a hydraulic or electric retarder or the like, can be arranged on any shaft, preferably on the input shaft 1 or the output shaft 2, which is especially of significance for use in commercial motor vehicles within the framework of a further, not represented embodiment of the invention. Furthermore, an auxiliary output can be provided on any shaft, preferably on the input shaft 1 or the output shaft 2, for driving additional units on each shaft.

[047] The shifting elements used can be constructed as power-shifting clutches or brakes. In particular, non-positive clutches or brakes such as multi-plate clutches, band brakes and/or cone couplings can be used. Furthermore, positive locking brakes and/or clutches, such as synchronizations or claw clutches, can be used as shifting elements.

[048] A further advantage of the multi-step transmission presented here consists in an electric machine being installed on each shaft as generator and/or as additional drive machine.

[049] The functional features of the claims can be configured in most different ways in terms of their design. These possible design embodiments are not

explicitly described for the sake of simplicity. Obviously, each design embodiment of the invention, nonetheless, falls under the scope of protection of the claims, especially any spatial arrangement of the planetary gear sets and the shifting elements in themselves and, in relation to one another, to the extent to which they are technically appropriate.

Reference numerals

| | |
|---|---|
| 0 | shaft |
| 1 | shaft |
| 2 | shaft |
| 3 | shaft |
| 4 | shaft |
| 5 | shaft |
| 6 | shaft |
| 7 | shaft |
| 00 | brake |
| 03 | brake |
| 13 | clutch |
| 36 | clutch |
| 45 | clutch |
| 47 | clutch |
| 67 | clutch |
| | |
| P1 | planetary gear set |
| P2 | planetary gear set |
| P3 | planetary gear set |
| An | input |
| Ab | output |
| I | reduction |
| φ | step progression |
| G | housing |